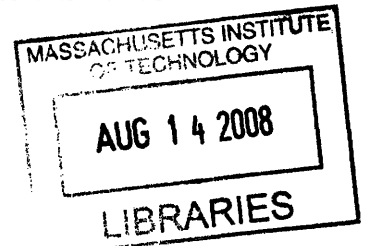


Design and Manufacture of a Low-Cost Mechanism for Compacting Used Oil Filters

by

Richard D. Kosoglow



SUBMITTED TO THE DEPARTMENT OF MECHANICAL ENGINEERING IN PARTIAL
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Richard D. Kosoglow

Submitted to the Department of Mechanical Engineering
on May 16, 2008 in partial fulfillment of the
requirements for the Degree of Bachelor of Science in
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ABSTRACT

Used automotive oil filter disposal is a real and increasing problem in the United States. With over 450 million oil filters sold each year, and 80% of used filters thrown into landfills, this waste represents a significant toxic waste problem for the country. There are a number of economic and technological challenges in improving the overall rate of proper disposal of these filters, one of which is a recycling and disposal system that currently provides monetary incentives for crushing, rather than cleaning these filters. This paper extends previous research done by a group of MIT students into a low cost device for effective compaction of used oil filters. Testing is done on compacting heads of various shapes to determine crushing geometries to improve volume reduction for a given load. As a result, a sample system is designed and presented which is estimated to achieve at least 15% compaction of used filters using only 1000 lb-force for less than \$200 in retail parts.

Thesis Supervisor: David R. Wallace

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I. ACKNOWLEDGMENTS

I would like to thanks Professor David Wallace for his support of my work in both his 2.009 class developing Cyclos, and during the development of this thesis. In addition, I would like to thank the rest of my team for 2.009 for making the long process that resulted in Cyclos very enjoyable. In addition, I would like to thank them for much of the research that inspired and helped create this thesis.

II. INTRODUCTION

Proper disposal of automotive oil filters is a large and growing problem in the United States. With more and more cars on the road each year, the number of filters replaced each year has also grown. In 2006, this number reached over 450 million filters(ref. 8). Unfortunately, estimates show that approximately 80% of these filters are improperly handled. Many are thrown into landfills without any sort of cleaning or processing after they are removed from vehicles. Many other filters undergo a minimal process of gravity draining which only removes 40-60% of the remaining oil in the filter, leaving the remainder to seep into landfills(ref. 7). Although toxic waste laws are very rarely enforced, EPA regulations dictate that if less than 70% of the oil is removed, the filter is still considered toxic waste and cannot be disposed of in a normal landfill. The facts about oil contamination make it clear why this is the case.

Depending on size and filter configuration, the amount of oil left in a used oil filter may be anywhere from 8 oz to 32 oz. To put this in perspective, 8 oz of oil is enough to contaminate 62,000 gallons of fresh water. Thus a single improperly handled filter may contain the potential to contaminate almost 250,000 gallons of water. However, when properly extracted and collected, the oil and steel within these filters can be recycled very effectively. For example,

although it takes 42 gallons of crude oil to create 2.5 quarts of lubricant, 1 gallon of used oil can produce the same amount. Similarly, the energy required to re-smelt steel is far less than the energy required to create new steel from raw ore. Given the sheer number of filters disposed of each year, if full participation in recycling programs were achieved, the U.S. would recover 250,000 barrels of oil and over 230,000 tons of steel each year(ref. 8).

In an attempt to address this problem, a group of MIT students designed a low cost oil filter cleaner in the fall of 2007. It was designed for use by small and medium sized automotive shops who are unable to afford current cleaning technologies. The students called their product Cyclos and the final solid models of the device can be seen in figure 1 below(ref. 8). However, many medium sized shops currently use crushers to reduce the volume of waste, since disposal costs are often based on volume. For these shops a cleaner without a crusher, no matter how inexpensive, costs them far more than just the price of the cleaner. In the extreme case for this market, a shop could end up paying over \$10,000 each year in added disposal fees by moving from a crusher to a cleaner.

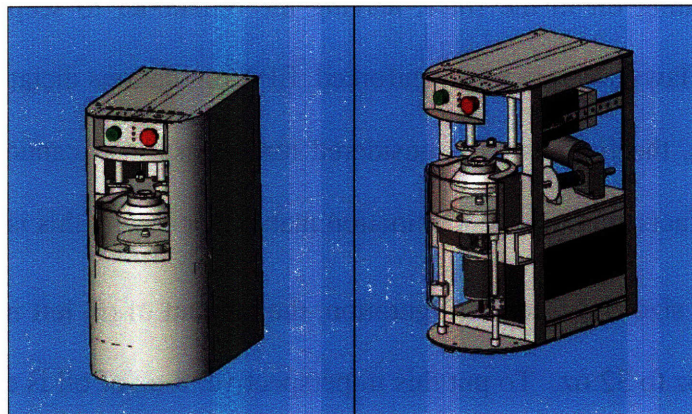


Figure 1: Cyclos Final Design

Due to time and resource constraints, the students chose not to design a crushing mechanism into their final system. This paper investigates some different methods of crushing

these filters in an attempt to provide design parameters and suggestions for a mechanism which may enable low cost cleaning solutions such as the one designed by the MIT students to become feasible for sale in a larger market.

Initial results from tests performed by these students indicated that nearly 6000 lbs of force would be required to achieve 50% volume reduction of these filters. This level of compaction was chosen because it is approximately the same volumetric reduction that many crushers on the market currently achieve. However, it is not clear that a reduced level of compression would harm sales of a system which can boast better cleaning performance. The results of further experimentation of oil filter crushing have shown that with only 1000 lbs of force, it is possible to achieve a reduction of approximately 30%. With some adaptation and further development, this may even be able to be improved closer to the 50-70% volume reduction of standard pneumatic crushers. This paper explores options for a system using low cost components to create a cheaper crushing mechanism aimed at this lower volume reduction. A simple system is proposed using less than \$200 in off the shelf parts and including critical dimensions and geometric descriptions of the system.

III. PRIOR ART

With over 450 million oil filters produced and changed each year, there have been a number of solutions already developed for handling these filters. These solutions range from do-it-yourself draining techniques to industrial shredders, each solution targeting a specific market among automotive shops. The following sections will discuss some of these solutions, their intended markets, and the advantages and disadvantages of each.

III A. INDUSTRIAL PROCESSING

Although industrial recycling methods have little bearing on which in-shop methods are used by automotive shops, a brief description of these processes is useful in order to understand some of the problems with crushing machines. Most facilities use some combination of shredding, burning, screw press, and smelting to reprocess the filters and the oil they contain (ref. 4,8). In shredding, the filters are put through a large metal shredder which turns them into scraps of metal and paper. The metal, being steel, can then be removed by passing strong magnets over the scrap that exits the shredder.

The oil filled paper scrap left after removal of the steel is then either burned as fuel for the smelting furnace which reprocesses the steel, or is fed through a screw press. The screw press forces the paper down a tapered screw which squeezes over 99% of the oil out of the paper. This oil can then be reprocessed into diesel fuel or lubricants significantly more efficiently than can unprocessed crude oil. The remaining paper is then either burned in the smelting furnaces or disposed of in landfills.

While it is much more wasteful, though not always unavoidable, some recycling centers do not bother to process the filters before putting them into the smelting furnace. Instead, the oil and paper left in the filter is burned out in the smelting process. Obviously this completely wastes the left over oil, and also severely increases the carbon emissions of the recycling facility. However, some crushers (described shortly) make the filter too dense to pass through a shredder without damaging the blades. Most recycling centers currently are forced to process these filters separately, smelting only a small amount of them at a time in order to avoid exceeding the center's allotted carbon emissions. This waste of resources motivated a project in the 2.009 class

at MIT in the fall of 2007 in an attempt to create a cost efficient way to remove oil from used filters by spinning them.

III B. SPIN CLEANING

Currently there is only one machine on the market which uses centripetal force to clean used oil filters. This is the TurboSpin Filterfuge (ref. 7), figure 1, which takes filters whose upper seal has been punctured and spins them to force the oil out. This removes 80-90% of the oil remaining in the filter and ensures that it is no longer

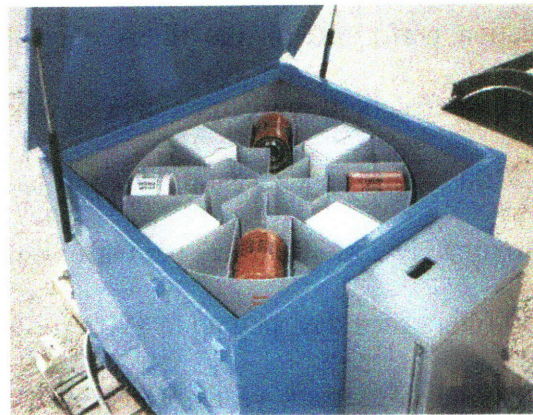


Figure 1: TurboSpin Filterfuge

considered hazardous waste by the EPA. The simple gravity drain method used in most shops removes only 40-60% of this oil by comparison(ref. 7). Thus, the Filterfuge is a great solution for removing the oil from the filters. However it costs as much as \$7000, making it too expensive for most small to mid sized shops.

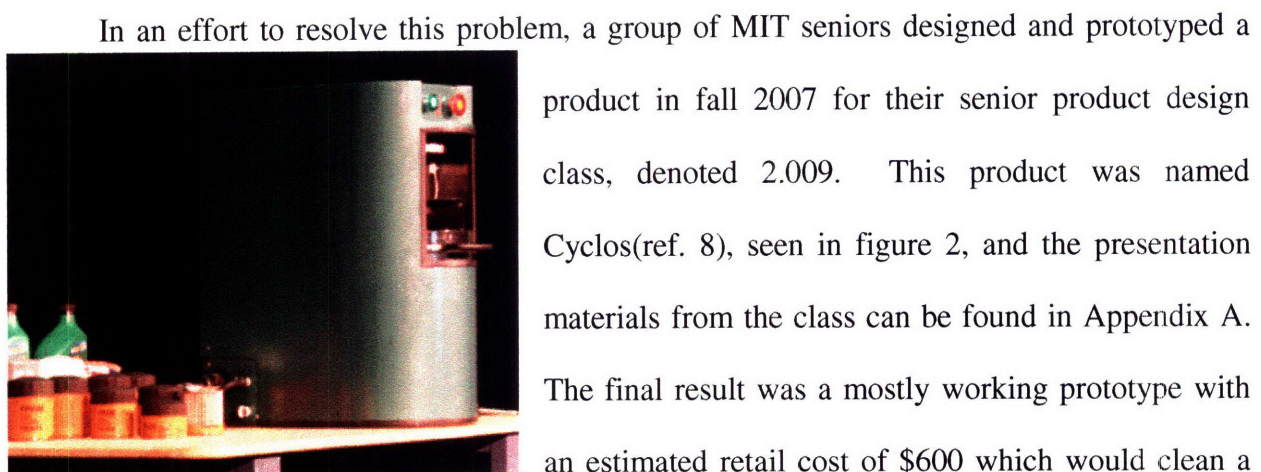


Figure 2: 2.009 class Cyclos prototype

In an effort to resolve this problem, a group of MIT seniors designed and prototyped a product in fall 2007 for their senior product design class, denoted 2.009. This product was named Cyclos(ref. 8), seen in figure 2, and the presentation materials from the class can be found in Appendix A. The final result was a mostly working prototype with an estimated retail cost of \$600 which would clean a single filter in approximately two minutes. By

comparison, the Filterfuge cleans 2 to 8 filters in 8 minutes(ref. 7). Cyclos appeared to achieve similar oil removal levels to the Filterfuge, but was not tested over as wide a range of filters due to time limitations for the class.

One of the major problems for both of these machines however, is that there is no volume reduction performed on the filters once they are cleaned. After talking with a number of recycling centers in the Boston area, it was determined that many of them charge between \$60 and \$100 to pick up a 55-gallon drum of used oil filters. With undamaged filters, this equates to approximately 250-300 filters per barrel if they are well packed. So the target shops, processing 20-50 filters each day, pay up to \$200 per week for disposal of their filters, resulting in \$10,400 in disposal costs each year. Thus, even a small reduction in oil filter volume can provide significant financial savings.

III C. CRUSHING MACHINES

There are a wide range of crushing machines on the market today ranging in price from around \$1000 to \$4000. These machines take all sizes of oil filters and crush them axially using pneumatic pistons. These machines generally achieve a 40-70% reduction in volume of the filter, making them ideal for oil changing shops who pay for disposal based on the volume of filters to be disposed of or recycled. Examples of these machines can be seen below in figure 3.



Figure 3: Examples of oil filter crushers (ref 2,5)

However, from an environmental perspective there is one significant problem with these systems: oil removal. Although the filters are compacted, the paper inside the filters which holds most of the remaining oil is not compressed enough to force out more than about 60% of the remaining oil (ref. 7). In fact, the now crushed cans are too dense for many recycling centers to process using shredders, and as a result, the oil is left inside the filters to be burned out during the steel re-smelting process. This is a huge waste of oil that can be effectively recycled, and also contributes significantly to carbon emission levels at recycling centers.

This is where the goal of this paper enters. While methods for cleaning oil filters exist, in many cases the financial incentive for customers to buy an oil filter disposal solution is in volume reduction. Thus this thesis explores low cost alternatives to large pneumatic systems that handle multiple filters at one time. The following sections of this paper will quantify the benefits of alternatives to crushing filters in the direction of their cylindrical axis as well as put forth a general design for the mechanisms of a low cost oil filter crusher.

IV. CRUSHING REQUIREMENTS

Initially, the team of students who created Cyclos investigated creating a crushing mechanism, but discarded the idea for reasons of complexity and time constraints. A set of tests were run to determine the force needed for successful compression of filters and it was determined that over 3 tons of force are required to achieve a 50% volume reduction of an STP brand model S8A filter, chosen because it was of a size near the average for normal automotive filters (not van or large truck).

As will be discussed in further detail in the following sections, there were two major problems with the approach taken by the students. Firstly, the students only tested crushing force requirements for a filter standing on end, an orientation which places the majority of the structural rigidity in the filter along the direction of compression. Secondly, the students assumed that a 50% volume reduction was required to make a competitive product. In reality, a low cost alternative to pneumatic crushers which could only achieve 20-30% reduction would still save a significant amount of money for shops using the technology, as well as permitting use of a crusher in smaller shops than are currently willing to pay \$1000 for a crushing mechanism

After more experimentation and investigation of force application methods, described below, it was determined that a more appropriate target would be to apply approximately 1000 lb of force and attempt to achieve as much compression with that force as possible. The justification for choosing this level of force can be found in the technical specifications section after the experimentation section below. With this target in mind, a design proposal is described for a simple crushing mechanism, and basic cost considerations of the proposal are discussed.

IV A. EXPERIMENTATION

Compression testing of a number of oil filters was performed on an Instron model 1125 Electromechanical Testing machine under a number of different conditions. The machine was programmed to apply a displacement to the filters up to 75 mm or until the maximum load of the testing machine was reached. This maximum force was never reached in these tests. The tested conditions were as follows: two levels of pre-deformation of the filter walls before applying force along the cylindrical axis, placing the filter horizontally and using a chisel shaped tool, and placing the filter horizontally and using a cylindrical tool. The force vs. displacement graphs,

along with photos and diagrams of the experimental setups can be found in Appendix B as tests 2 through 5. Test 1 is the data obtained by the 2.009 students.

However, volume reduction, rather than displacement, is the measure of interest to this study since filter disposal is often charged by volume. There is also significant potential benefit in changing the shape of the filters for improved packing density, however this study did not extend to that facet of the problem. In order to determine the volume change obtained by a certain displacement, the amount of displacement at 1000 lb-force load was found from the experimental data. This information, along with the geometry of the tool tip, permitted an estimate to be made for the change in volume achieved at this level of force. Table 1 below summarizes the results of this estimation. Note that there was little change in the compression of vertically oriented filters as a result of the pre-deformation, so the data from all three trials is combined into one row of the table.

Table 1: Volume reduction estimates from experimental data

Total volume of the filter before compression is approximately 47.09 in ³		
	Vol at 1000 lb-force (in ³)	% Reduction Estimate
Vertically oriented filters	42.97	8.75
Horizontal filter, chisel tool	39.42	16.29
Horizontal filter, cylindrical tool	32.29	31.43

As can be seen from the cylindrical tool data, a 30% volume reduction is indeed possible at 1000 lb-force. In fact, the data collected for this shape never reaches 1000 lb-force, instead reaching the end of the programmed displacement applying just over 600 lb-force. However, the raw data is potentially misleading. A perfunctory examination of the crushed filter using this tool tip shows the reason for this very desirable result. As can be seen in figure 4, the wall of the

filter sheared under the applied load. This event allowed the crushing tool to bend a thin sheet of steel along with the paper, while isolated from the steel plate located at the open end of all oil filters which provides structural support for the filter.

However, while the over 30% reduction from the cylindrical tool is suspect since a means of consistently producing this shear was not developed, the results of the chisel tool experiments show that there is promise even without this effect. With a chisel shaped tool, test 5 in appendix

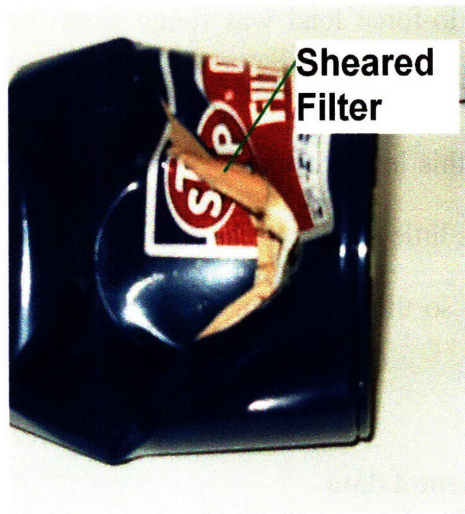


Figure 4: Shear in wall of filter crushed by cylindrical tool

B, more than 15% reduction was achieved before exceeding 1000 lb-force. This amount of volume reduction, utilized in a setting where volumetric filter pickup costs are approximately \$10,000 each year, as discussed in the spin cleaning section of this paper, would result in a savings of approximately \$1500 each year.

As an additional note, one test was attempted in which the filter was turned horizontally between the two flat plates used in tests 1 through 3 in appendix B. However, the curvature of the filter, in conjunction with the fact that there is only a structural plate on one end of this filter, caused a large torque to quickly be applied to the force application arm. This torque was potentially damaging to the test apparatus, so the test was aborted before any meaningful data could be obtained. However, the test demonstrated that in any mechanism to crush these filters, alignment would be critical to prevent damage to the crushing apparatus.

Using the experimental data, along with visual inspection of the crushed filters, a number of specifications and design suggestions were developed for use in creating a low-cost crushing mechanism. These design details are presented as individual components and systems in the specifications section, and then as a system setup in the proposed design section following.

IV B. SPECIFICATIONS

As has been mentioned several times in this paper, a force limit of 1000 lb was determined to be reasonable for the desired low cost mechanism. This limit was calculated by first finding the mechanical advantage possible by using a standard lead screw setup and then researching different motors to determine a reasonable amount of torque that can be obtained from a low cost motor. For the purposes of this project, the desired cost of motor and gearbox was less than \$100 retail, as the components for the lead screw system and a simple box extrusion frame retail for less than \$100. These costs mean that an integrated system, manufactured in bulk, could potentially be sold with a machine like Cyclos while only adding \$200-300 to the overall cost of the machine. This price level would allow the complete cleaning and crushing system to be price competitive with current crushing systems while cleaning the filters much better.

The governing conversion equation from applied torque to resultant force for a lead screw system without a pre-load is given by equation 1:

$$T_m = \frac{1}{2 \cdot \pi} \cdot \frac{F_l}{P \cdot e} \quad (1)$$

where T_m is the torque to the motor in inch-pounds, F_l is the force on the load in pounds, P is the pitch in revolutions per inch, and e is the efficiency of the lead screw. Available data estimates the efficiency of standard ACME lead screws to be between 10% and 40%. Taking a conservative estimate of this value, and using a 1"-10 lead screw for strength in supporting the large loads involved, the motor required for producing 1000 lb-force needs to produce at least 160 in-lb of torque. A quick web search provides numerous examples of geared motors capable of more than double this torque while operating at a speed that would enable full compression and retraction of the crushing mechanism in less than 15 seconds.

Specifically, a number of motors currently selling for less than \$100 are capable of providing around 3000 lb-force in this system, allowing them to easily run within a comfortable operating range while applying 1000 lb-force to a filter. Thus, a basic crushing mechanism may be created by connecting one of these motors to a lead screw attached to a crushing head. The results of the testing described earlier in this paper show that there may be significant advantage obtained if a crushing head may be shaped such that the walls of the used oil filters are consistently sheared, rather than merely deformed. However, the research done for this paper did not extend to an examination of different head shapes beyond the chisel and cylinder used for initial testing. It is hypothesized that a sharp edged crushing head, small enough to effectively avoid the steel plates that support at least one end of every filter may be able to achieve these results. Technical drawings of the proposed head shape can be found in Appendix C and further details may be found in the following section of this paper which describes a rough system for further testing.

One more constraint for the design of this crushing system is the prevention of tangential loads on the lead screw. The solution for this part of the problem will involve both proper

constraint of the lead screw and crushing head as well as a method to prevent the filter from slipping on the fixed crushing plate. A proposed solution is included in the next section as well, and is chosen for its simplicity to manufacture as well as relatively low material costs. Further description of this component will be left for the next section so that it may be described along with its role in the system.

IV C. PROPOSED DESIGN

Although a prototype of a crushing mechanism such as the one described in this paper was not fabricated, after experimentation and data processing a rough design for a crushing mechanism was created. The intention of this design is to provide direction for further testing of the results presented herein. Thus, it incorporates all technical specifications as described previously as well as permitting a range of adjustments to be made for further experimentation. Figure 5 below shows a solid model of the proposed design which will shortly be described in further detail. Also, technical drawings with critical dimensions can be found in Appendix C.

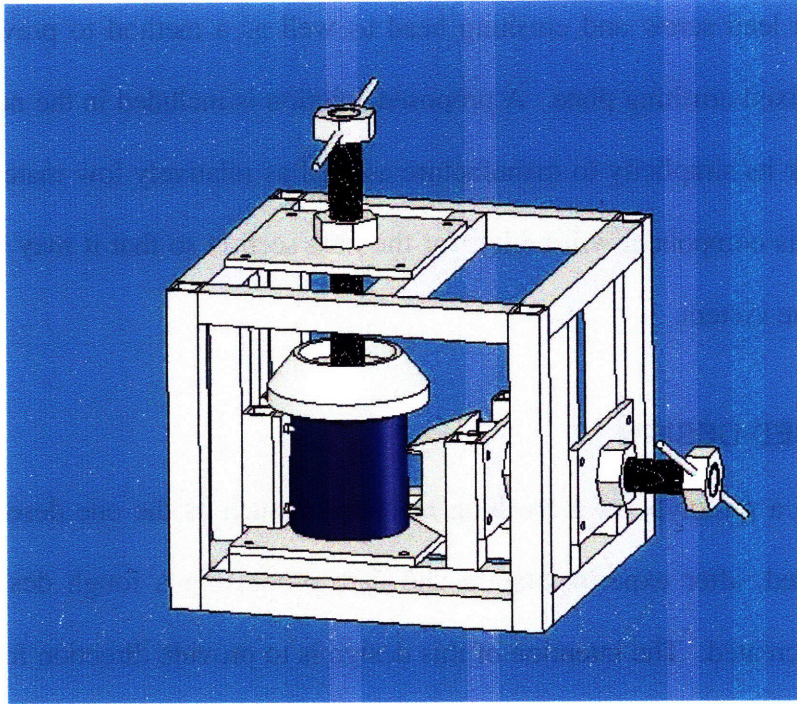


Figure 5: Solid Model of proposed design for further testing and refinement

This design consists of three simple modules: frame, clamp, and crusher, shown in figure 6. Of these, only the frame and crusher are needed for the volume reduction that is desired. The clamping mechanism merely allows a more substantive parallel to be drawn between the proposed crushing mechanism and the method of gripping an oil filter used in the Cyclos project as discussed previously. It consists of a simple lead screw mechanism attached to a semi-conical top plate, clamping the filter to a flat bottom plate. The semi-conical top plate allows for filters of different diameters to be effectively held, and is the same size and shape as that used for Cyclos.

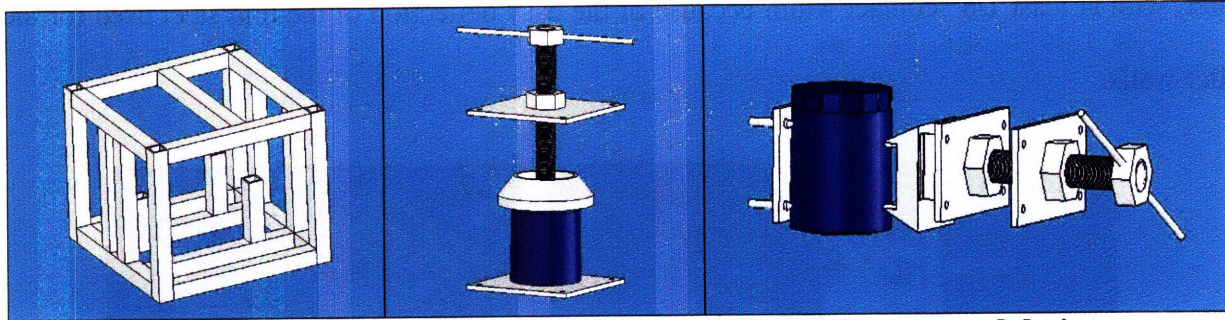


Figure 6: Frame, clamping, and crushing systems for the proposed design

Similarly, the framing system is a simple collection of 1" square box extrusions with 1/8" walls. The purpose simply being to allow for testing of the proposed crushing mechanism rather than any aesthetic or manufacturing considerations. The most important note about this part of the design is that the overall dimension is 10" x 10" x 8" which comfortably fits inside the footprint of the Cyclos oil filter cleaner and demonstrates that, while not necessarily simple, an integrated design is possible. For the actual manufacture of this frame, a system such as 80/20 T-slotted extrusions would be useful in order to allow for slight repositioning of pieces throughout the testing process. Thus an optimal height for the crushing mechanism could be determined for a final welded or bolted system.

The crushing mechanism itself consists of a flat fixed plate with holding spikes, a moving crusher wedge with steel blades, and a simple lead screw. The fixed plate and crusher wedge models are shown in figure 7 below. The flat plate is 1/4" general purpose low carbon steel. This gives the plate a yield of approximately 30 to 35 ksi, far higher than any forces that will be exerted by this mechanism. As the system is designed to support approximately 1000 lbs of force at the most, this plate will never be subject to pressures over 2 ksi since even before significant deformation, the crushing force is spread over an approximately 4" height of the

filter, with at least 1/8" contact width because of the easy deflection of the thin steel used for the filter walls.

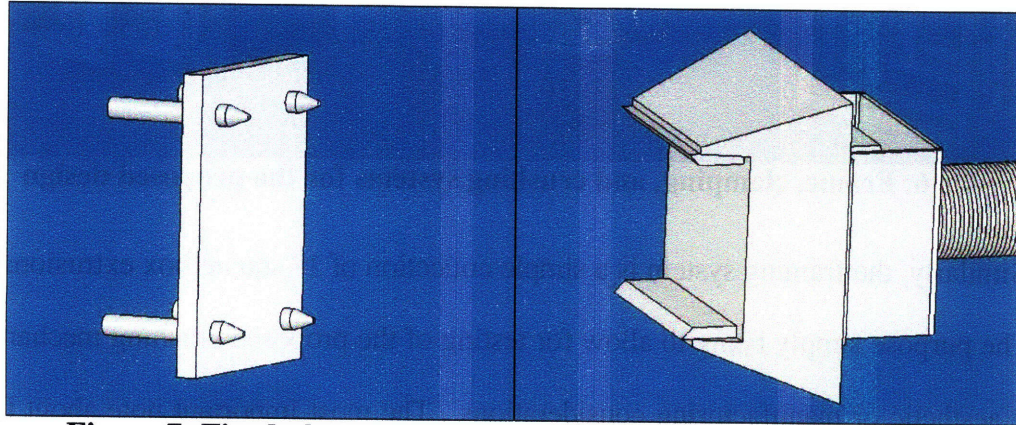


Figure 7: Fixed plate and crushing wedge solid models

Embedded in this plate are four 1/4" rods with sharpened tips to prevent the filter from slipping. As discussed in the experimentation section of this paper, during some attempts to crush filters from the side the filter moved off center on the crushing plate, exerting a torque on the crushing rod that was potentially damaging. These sharpened rods work as both a centering mechanism as the filter is pushed into the plate as well as puncturing or denting the filter wall as crushing occurs, further reducing the chance that the filter will slip. For a rough fabrication, it may be convenient to leave the rods long in order to use the back side of the rods as bolts for fixing the flat plate to the structure of the mechanism. This is shown in the rods in figure 7 which extend far beyond the back of the fixed plate.

The crushing wedge proposed here is tapered vertically and horizontally towards the front and has two blades attached to the inner surface of the ridges. The angles and dimensions involved can be seen more clearly in the technical drawings included in Appendix C. The intent of this design is to impact the filter well within the edges of the steel, similar to the cylindrical

crushing tool used for force experimentation, while focusing the force on two thin surfaces. With further testing and development it is believed that such a design may result in consistent shearing of the filter walls, increasing the volume reduction for a given load force.

Construction of the crushing wedge itself is relatively simple and can be accomplished using a bandsaw to cut the rough tapers and cutouts required into a block of steel. For a more refined model, a cast or CNC milled part may be desirable, however this level of precision is unnecessary for the next steps in the development process of this mechanism. The blades attached to this head should be made from tool steel, as they will bear the highest loads in the mechanism. The stock for these blades is also readily available and more specific dimensions are included in Appendix C.

IV D. GENERAL COST CONSIDERATIONS

While a crushing mechanism similar to this would be able to provide value to the user through volume reduction of waste filters, the motivation for this work was the desired reduction in both steel and oil waste that resulted in Cyclos. Thus, the current designs include both the clamping mechanism and a tightly packed crushing frame in order to validate the assertion that this mechanism is fully capable, from a dimensional perspective at least, of being integrated into the Cyclos oil filter cleaner design.

As described in the literature from the 2.009 class last term, included in Appendix A, Cyclos targets the market of small to mid-sized shops. These shops handle 20-50 oil filters each day and process them in a variety of ways, from simple disposal to shipping them to recycling centers. While shops who throw away their filters have little incentive to crush them, those sending filters to recycling centers do in fact have a large incentive to crush, rather than clean

them. As discussed in the spin cleaning section of this paper, neither the Filterfuge nor Cyclos currently integrate any sort of compacting of the cleaned filters. This makes crushers far more appealing economically than either of these options. Unfortunately, as described previously, standard crushers do little to remove oil and also often force recyclers to burn the oil out instead of extracting it.

Thus, a low-cost crushing system such as is put forth in this paper, capable of only 10-20% volume reduction may save mid-sized shops as much as \$2,000/year, greatly increasing the attractiveness of the Cyclos product. However, when compared to the approximately 50-60% reduction obtained with pneumatic crushers the true incentive to buy this product will still need to be a desire for waste reduction or a legal mandate to reduce the polluting disposal of these resources.

V. CONCLUSION

While the problem of oil filter disposal and recycling in the U.S. is large, the mechanisms that may alleviate the problem are not excessively complex. The work done previously in the development of Cyclos, coupled with further design work based on this thesis may be used to develop a system that both cleans used filters in order to help the environment and crushes the filters to increase the economic incentive for shops to purchase the system. While economic estimates of this potentially low cost system show that current crushers may be more cost effective by as much as \$4,000 each year, increasing environmental pressures may soon force the adoption of less cost effective technologies. Either through government mandate or increased enforcement of current toxic waste disposal laws.

The system described in this thesis may quite reasonably be constructed for less than \$200 in retail parts, suggesting that a fully developed and mass produced system would likely be able to be sold for less than \$400. With current crushers selling for between \$1000 and \$4000, there may be a niche market within the 400,000 small to mid sized shops in the country that allows for a successful introduction of low cost, though potentially less effective solutions. Furthermore, with the limited work that has been done on the subject, it is entirely possible that future research and development will obtain equivalent effectiveness as current solutions at a fraction of the cost through exploration of filter wall shearing methods during compaction.

VI. FUTURE WORK

There are a number of considerations for further work in both the design and research areas of this project. At this point the two areas are closely linked, since a test system would be helpful for both testing new crushing head shapes as well as the ability of low cost components to duplicate the results from a high cost, high precision compression testing machine. First, such a low cost setup should be constructed in order to both validate the applicability of these results to less expensive systems, as well as provide a test setup from which data can be collected for more refined technical specifications. Then, further testing should be done on crushing head shapes and the potential value in developing cutting blades to induce shear in the oil filter walls.

Beyond work into optimizing the crushing head shape, there are a number of system design factors which must be considered. Since the goal of this mechanism is to enable cleaning machines such as Cyclos to be economically competitive with non-cleaning crushers, an integration of this crushing system into such a cleaner will likely be desirable. Alternatively, opportunities for this design as a standalone crusher may also be worth exploring, as it could then be sold as a complementary product to any filter cleaner that is developed.

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APPENDIX A: "CYCLOS" MATERIALS

Brochure Page 1/2

Product Need



A single improperly discarded oil filter can contaminate **62,000 gallons** of drinking water.

450 million filters are discarded every year, **80 percent** in landfills. This wastes **25.5 million gallons** of recyclable oil and **230 thousand tons** of steel.

1 gallon of used oil can produce **2.5 quarts** of lubricant.

Gravity draining takes **24 hours** to remove only **40 to 60 percent** of oil.

With the Cyclos, you can remove **80 percent** of used oil in **2 minutes**. That means you can double the amount of oil removed while decreasing the drain time by a factor of 720!

The Cyclos helps auto shops prepare oil filters for disposal quickly and easily, facilitating environmentally safe practices. Not only does it keep hazardous waste out of landfills, it allows the useful materials in the oil filters to be recovered and recycled.

Acknowledgements

Special thanks to:

2.009 Faculty and Mentors

Pappalardo Labs Staff

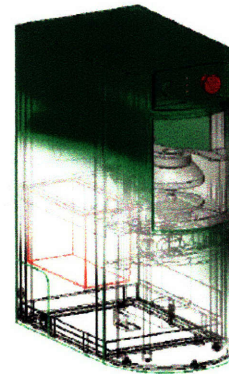
Ray Magliozzi and Good News Garage



2.009 Green
Fall 2007



Oil Filter Cleaner



2.009 Green

Fall 2007

How It Works

User Interaction:

- Take the dirty oil filter and place it in the machine.
- Close the door and hit the start button.
- Cyclos takes care of the rest!

Automated Process:



The pneumatic cylinder clamps the filter between two aluminum plates.



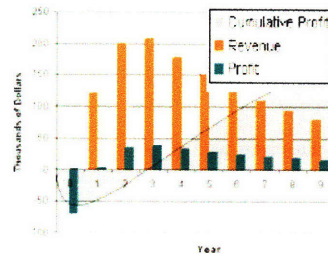
The punching mechanism drills 4 holes around the circumference of the filter.



The Cyclos spins the filter at 1000 RPM's for two minutes.

Gravity Drain	CYCLOS
50% oil removed	80% oil removed
24 hours	2 minute cycle
Hazardous waste	Recyclable

Business Model



- Market Size: 400,000 small- to medium-sized repair shops
- Product Lifetime: 10 years
- Production Volume: 1000 machines per year
- Manufacturing Cost: \$280
- Retail price: \$600
- **Return on Investment: 30%**
- **Payback Period: 3 years**

Client Feedback:

"...there is a need for this product...to capture a higher percentage of the oil and do it quicker."

-Wayne, SaveThatStuff

This product would leave our garage less vulnerable to EPA fines for improper disposal of hazardous waste.

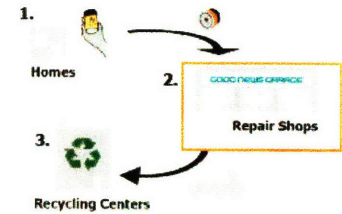
-Ray Magliozzi, Good News Garage

"Very cool machine."

- Peter Pasquier, Safety-Kleen

Market

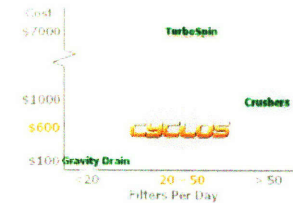
The Oil Filter Recycling Process:



1. Owners change oil every 3000 miles.
2. The oil filters are drained at repair shops.
3. Filters and used oil are picked up by recycling companies. The steel is recycled and the used oil is re-refined or used for heating systems.

Cyclos allows repair shops to efficiently drain oil from the used oil filters that they collect.

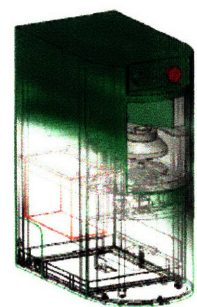
Competitors:



Current draining methods do not meet the needs of most small- to medium-sized auto repair shops. Shops that change 20 to 50 filters a day are excited to have a product that is affordable and suits their needs.

CYCLOS

Oil Filter Cleaner



Problem

One used oil filter can contaminate **62,000 gallons** of drinking water.



450 million filters are discarded every year, **80 percent** in landfills. These filters contain **25 million gallons** of used oil and **230,000 tons** of steel that can be recycled.

Gravity draining takes **24 hours** to remove only **40 to 60 percent** of used oil from filters.

Product

The Cyclos was designed to minimize user interaction. The user places a used oil filter on the centering pin, closes the door, and presses the start button. The Cyclos takes care of the rest.



The pneumatic cylinder clamps the filter between two aluminum plates.



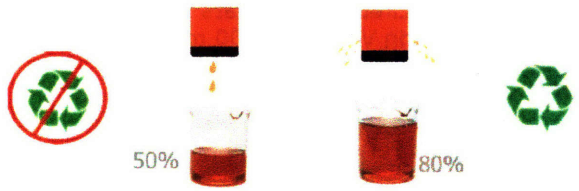
The punching mechanism drills four holes around the circumference the filter.



The Cyclos spins the filter at 1000 RPM's for two minutes.

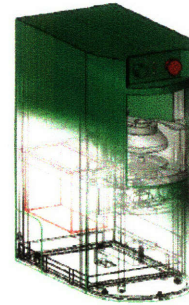
Gravity Draining	CYCLOS
50% Oil Removed	80% Oil Removed
24 Hours	2 Minute Cycle
Hazardous Waste	Recyclable

The Cyclos extracts 80 percent of used oil from filters, making the filters non-hazardous, and ready to recycle. It outperforms gravity draining by 60 percent in much less time.



CYCLOS

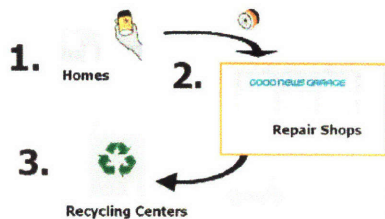
Oil Filter Cleaner



Market

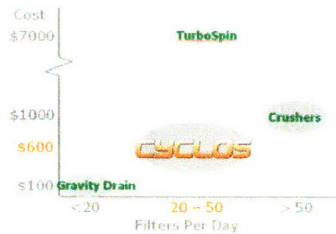
"There is a need for this product to capture a higher percentage of the oil and do it quicker"
Wayne, SaveThatStuff Recycling Center

The Oil Filter Recycling Process:



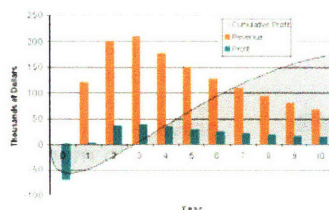
1. Car owners change oil filters every 3000 miles.
2. The oil filters are drained at repair shops.
3. The drained filters and used oil are picked up by recycling companies. The steel is recycled and used oil is re-refined or used for heating systems.

Our product is intended to be used by repair shops to efficiently drain the oil from the used car oil filters that they collect.



Current draining methods (gravity draining, crushers, and the TurboSpin) do not meet the needs of most small- to medium-sized auto shops. Shops that change 20 to 50 filters a day are excited to have a product that is affordable and suits their needs. At a retail price of \$600, the Cyclos is competitively priced for our intended market.

Business Model



Market Size: 400,000 small- to medium-sized shops
 Product Lifetime: 10 years
 Production Volume: 1000 machines per year
 Manufacturing Cost: \$280
 Retail Price: \$600
 Return on Investment: 30%
 Payback Period: 3 years

APPENDIX B: CRUSHING TEST DATA AND IMAGES

Test 1

Vertically oriented filter with no damage, crushed between two plates

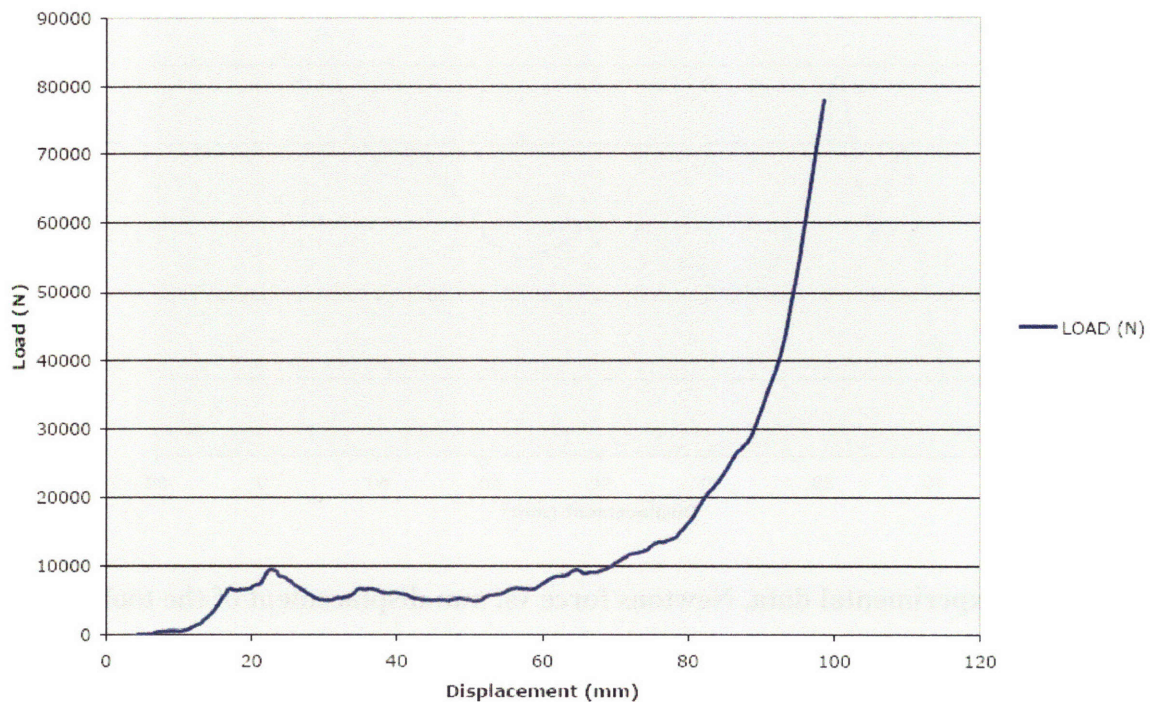


Test Setup



End Result

Vertical Filter, No Damage



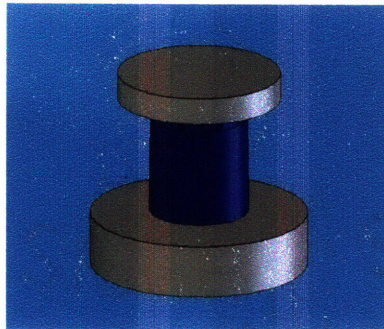
Plot of experimental data, Newtons force vs. mm displacement of the tool tip

Test 2

Vertically oriented filter, with a small indentation on one side crushed between two flat plates



Initial Dent

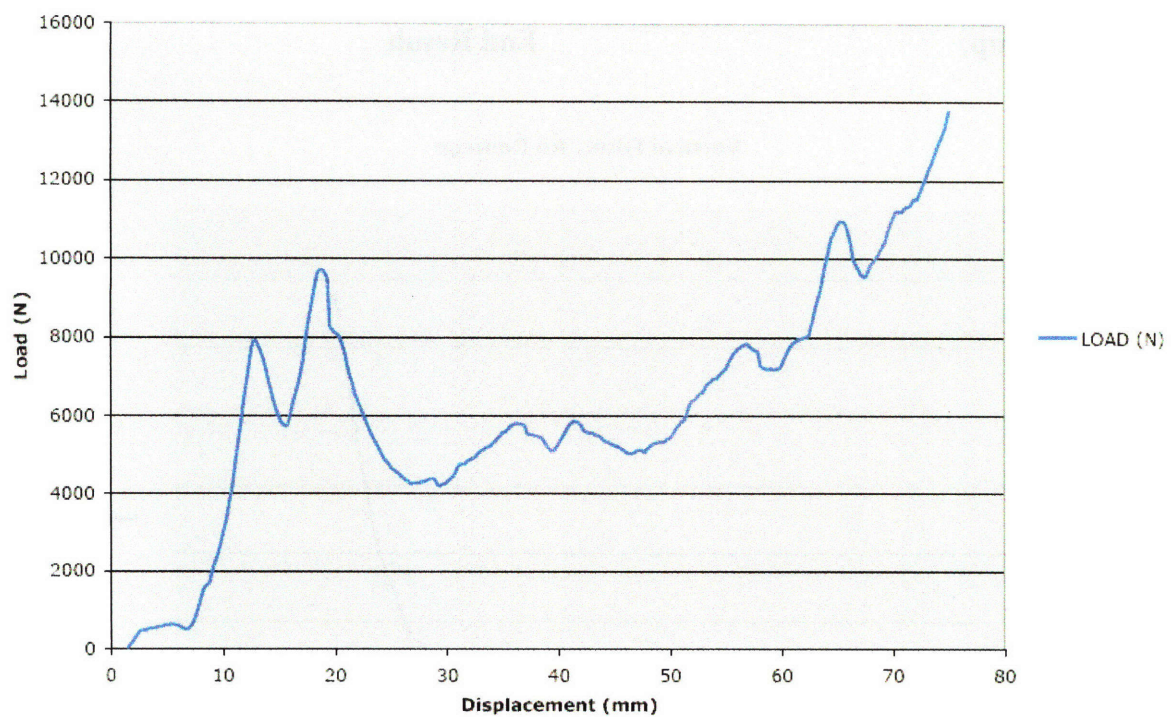


Crushing setup



End Result

Vertical Filter, Small Dent



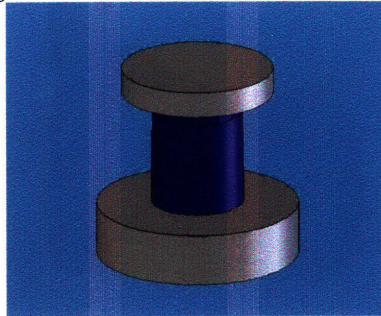
Plot of experimental data, Newtons force vs. mm displacement of the tool tip

Test 3

Vertically oriented filter with larger indentation in one side, crushed between two flat plates



Initial Dent

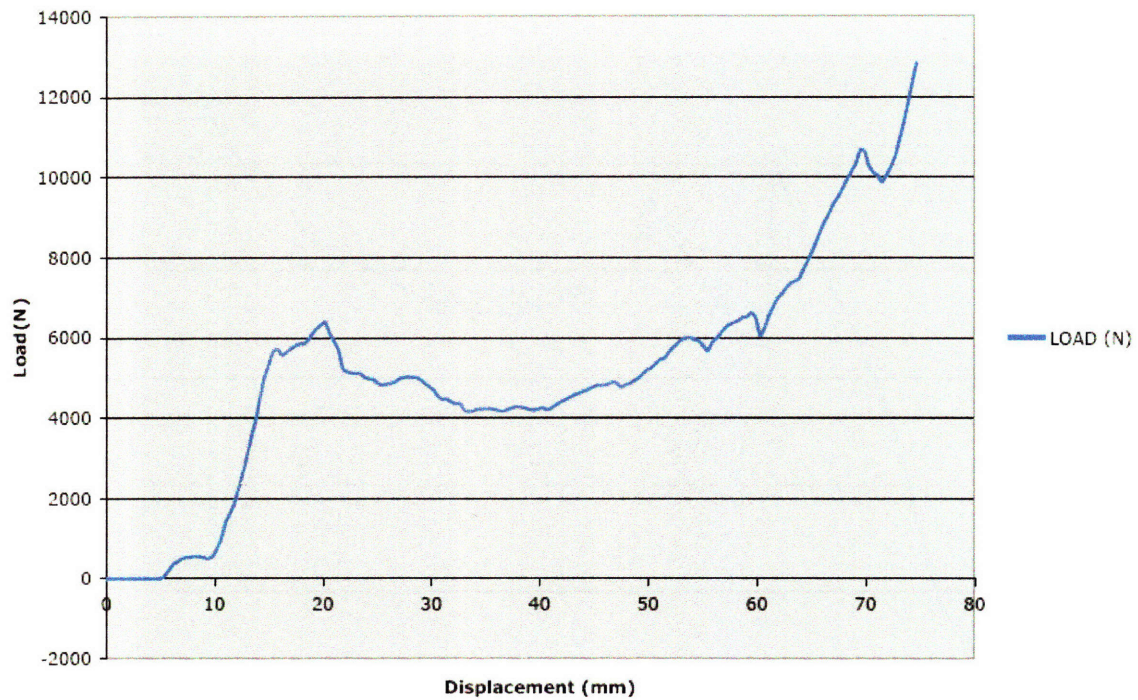


Crushing Setup



End Result

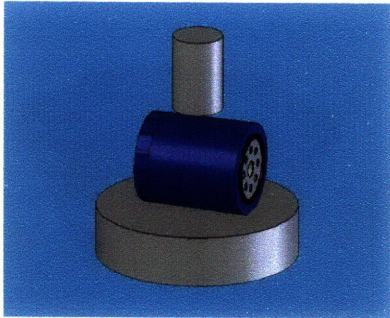
Vertical Filter, Large Dent



Plot of experimental data, Newtons force vs. mm displacement of the tool tip

Test 4

Horizontally oriented filter undamaged, crushed with cylinder tool



Crushing Setup

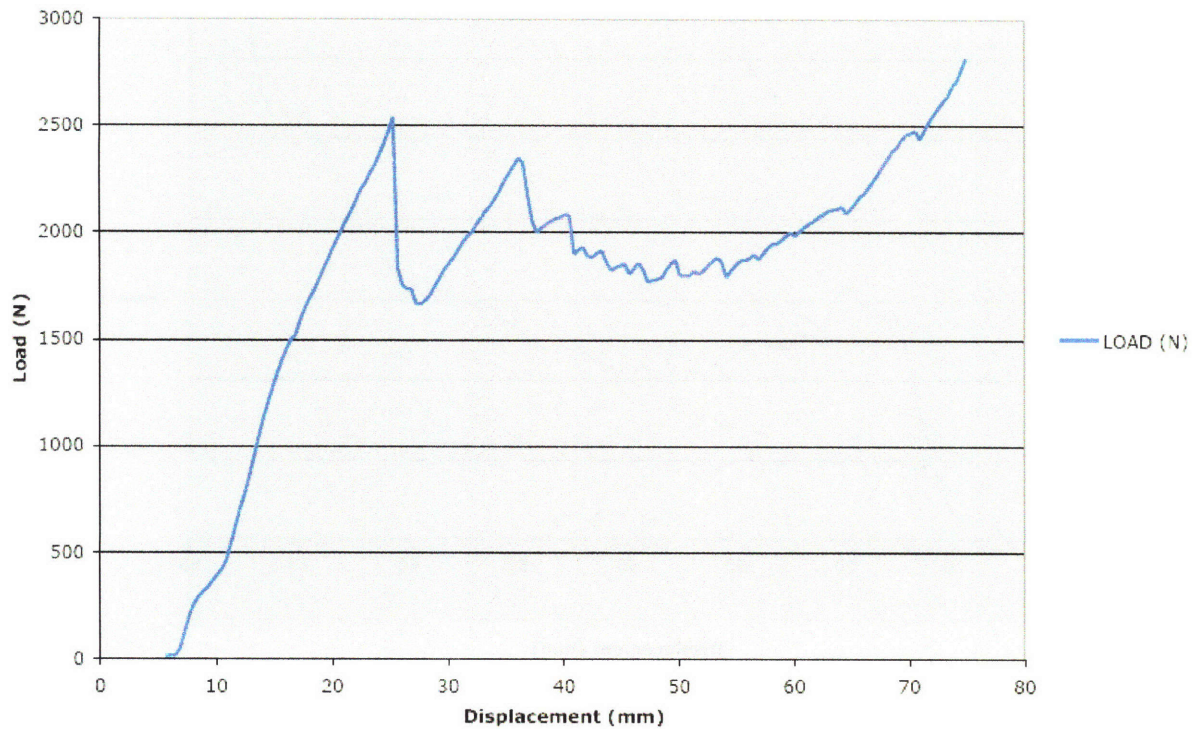


End Result Side View



End Result Top View

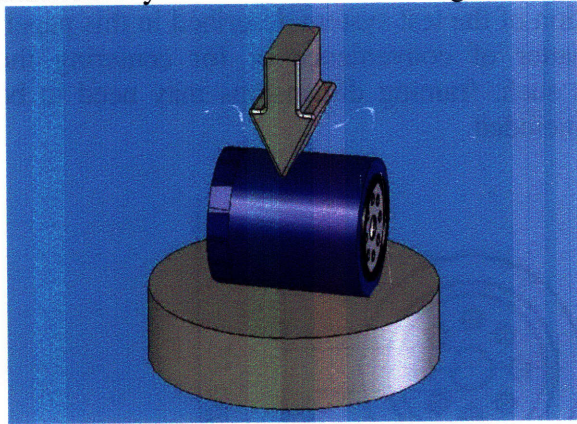
Horizontal Filter, Cylinder Crushing Tool



Plot of experimental data, Newtons force vs. mm displacement of the tool tip

Test 5

Horizontally oriented filter undamaged, crushed with chisel tool

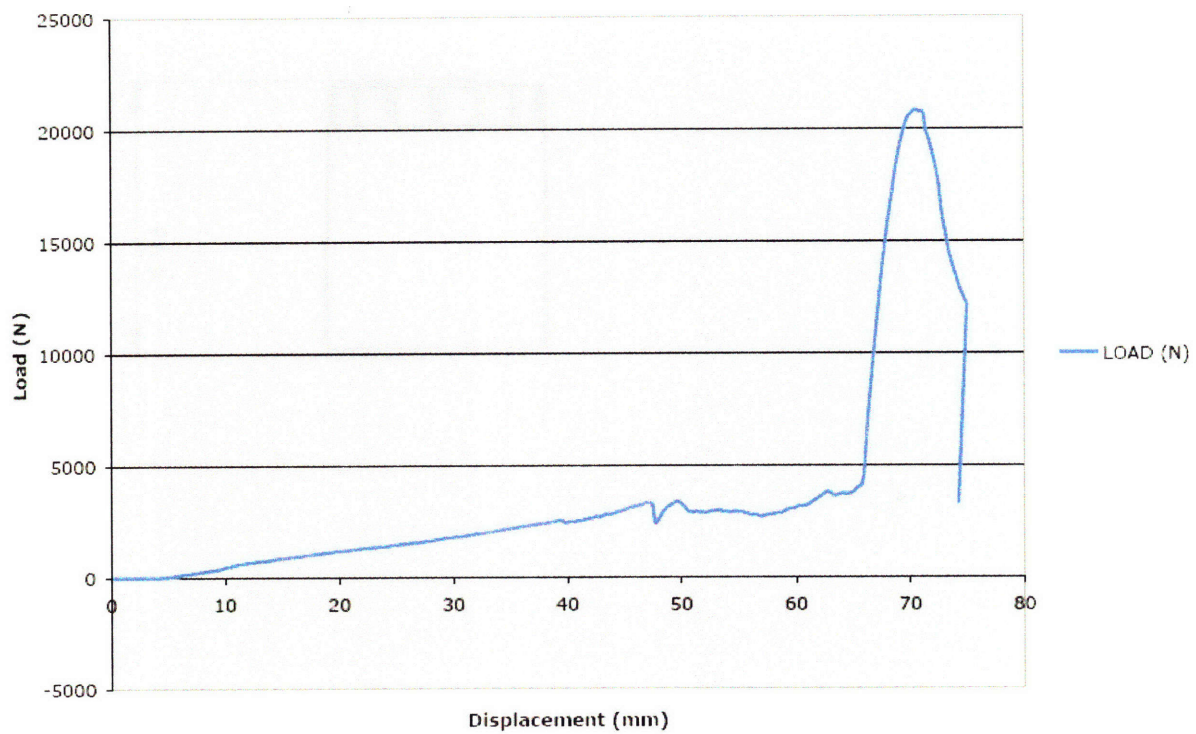


Crushing Setup



End Result

Horizontal Filter, Chisel Tool



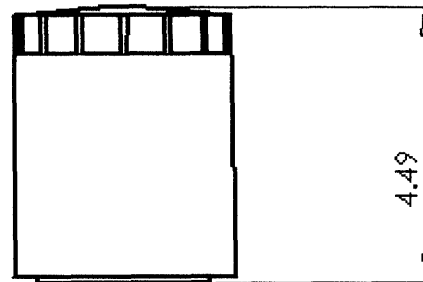
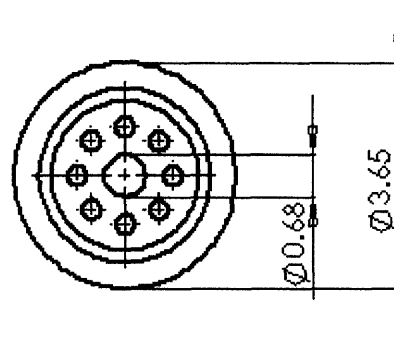
Plot of experimental data, Newtons force vs. mm displacement of the tool tip

APPENDIX C:

Technical Drawings – only critical dimensions are shown.

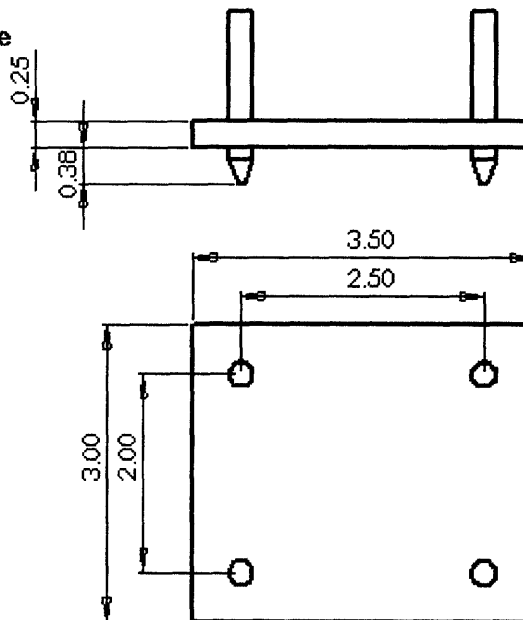
These drawings are intended to assist in the fabrication of the test system described in this paper. Many dimensions of the solid models are a matter of convenience or for centering the mechanism on the STP model S8A oil filter. As such, framing dimensions may need to be varied to adjust for different filter sizes and are not included.

STP brand S8A automotive oil filter
All dimensions are in inches

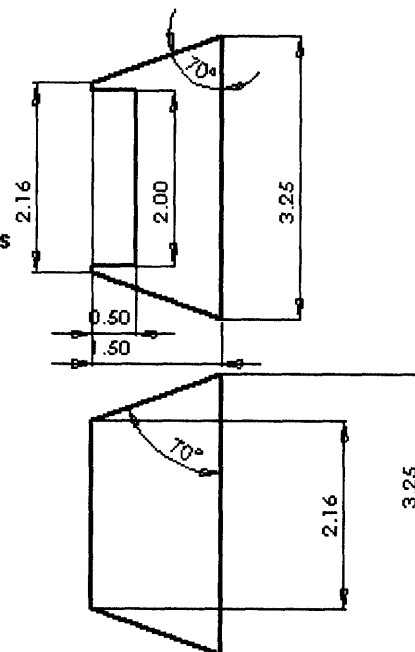


**Fixed Crushing Plate
with sharpened rods**

All dimensions are
in inches

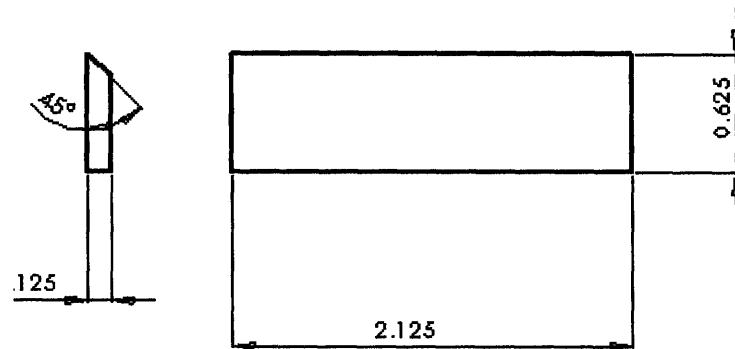


**Crushing Wedge
all dimensions are in inches**



Shearing blade

all dimensions in inches



System Setup

